Fire and weather

How well can we predict fire from weather? how much is weather modified by fires?

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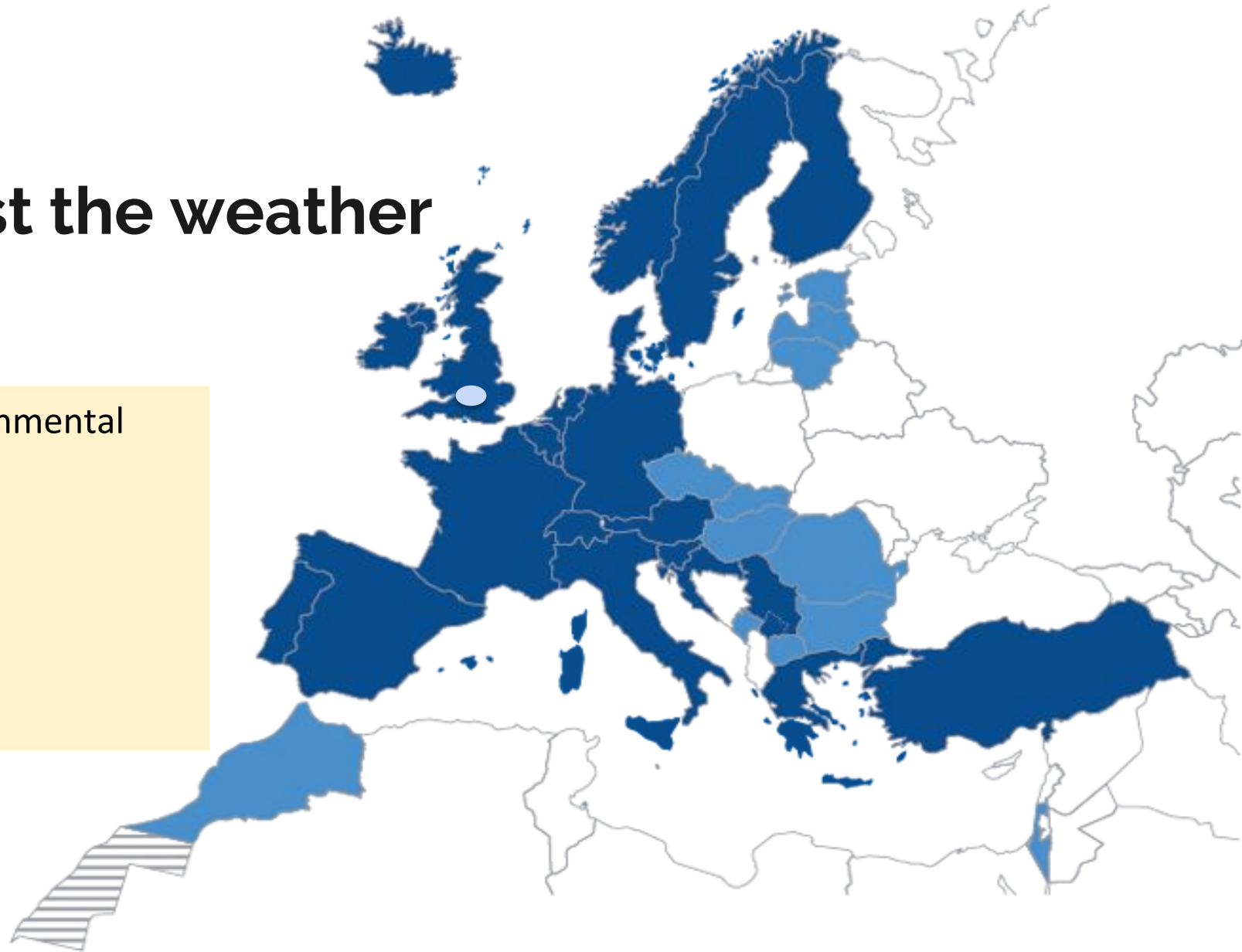
ECMWF

Who we are and what we do

@ECMWF we forecast the weather

ECMWF is an independent intergovernmental organisation established in 1975

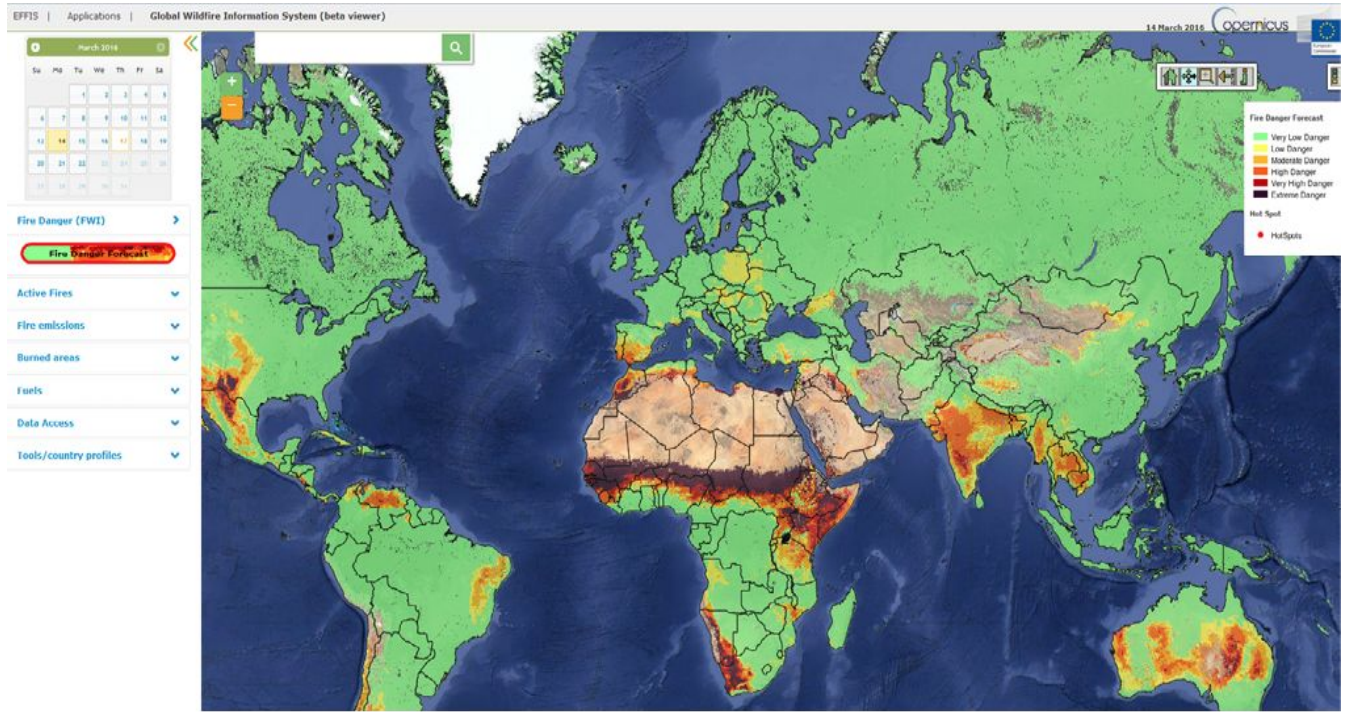
With
22 Member States
12 Co-operating States



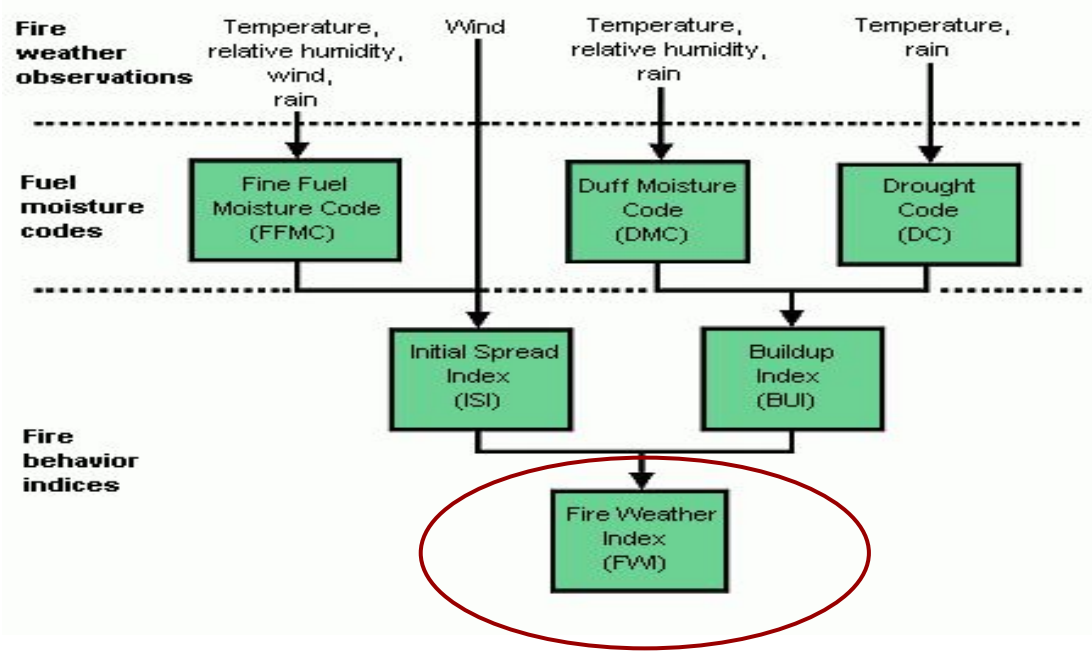
Fire forecast @ECMWF

The European Forest Fire Information System (EFFIS) is one of the products in support of natural disaster management provided by the Copernicus Emergency Management Service

The EFFIS platform is being expanded into the Global Wildfire Information System (GWIS) which aims at the creation of an integrated system that provides access to all fire related available information on a global scale.



How do we forecast fire danger? Here an example using the FWI

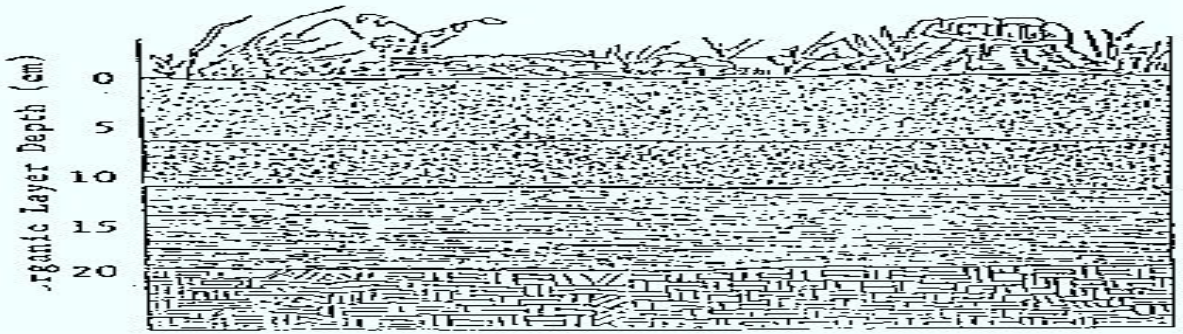


Three non interactive fuel layers

Drying depends on long and short term temperature, humidity and precipitation conditions

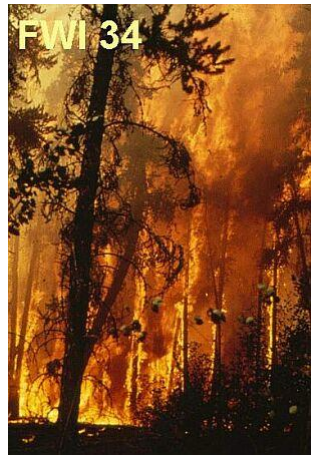
Wind mostly controls inflammability

Combinations of dryness and inflammability produces a general index of fire danger called Fire Weather Index



	Weight	Fuel Moisture Code
Duff Layer	5 t/ha	FFMC
Upper Middle	50 t/ha	DMC
Lower	440 t/ha	DC
Mineral Soil		

Example of Fire danger index “meaning” (FWI)



Fire Danger Ratings give you an indication of the consequences of a fire, if one was to start. The higher the fire danger, the more dangerous the conditions.

Fire Danger Ratings should be used as a trigger to take action to prevent or control a possible fire

Alexander, M.E.; De Groot, W.J. 1988. Fire behavior in jack pine stands as related to the Canadian Forest Fire Weather Index System. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Poster with text.

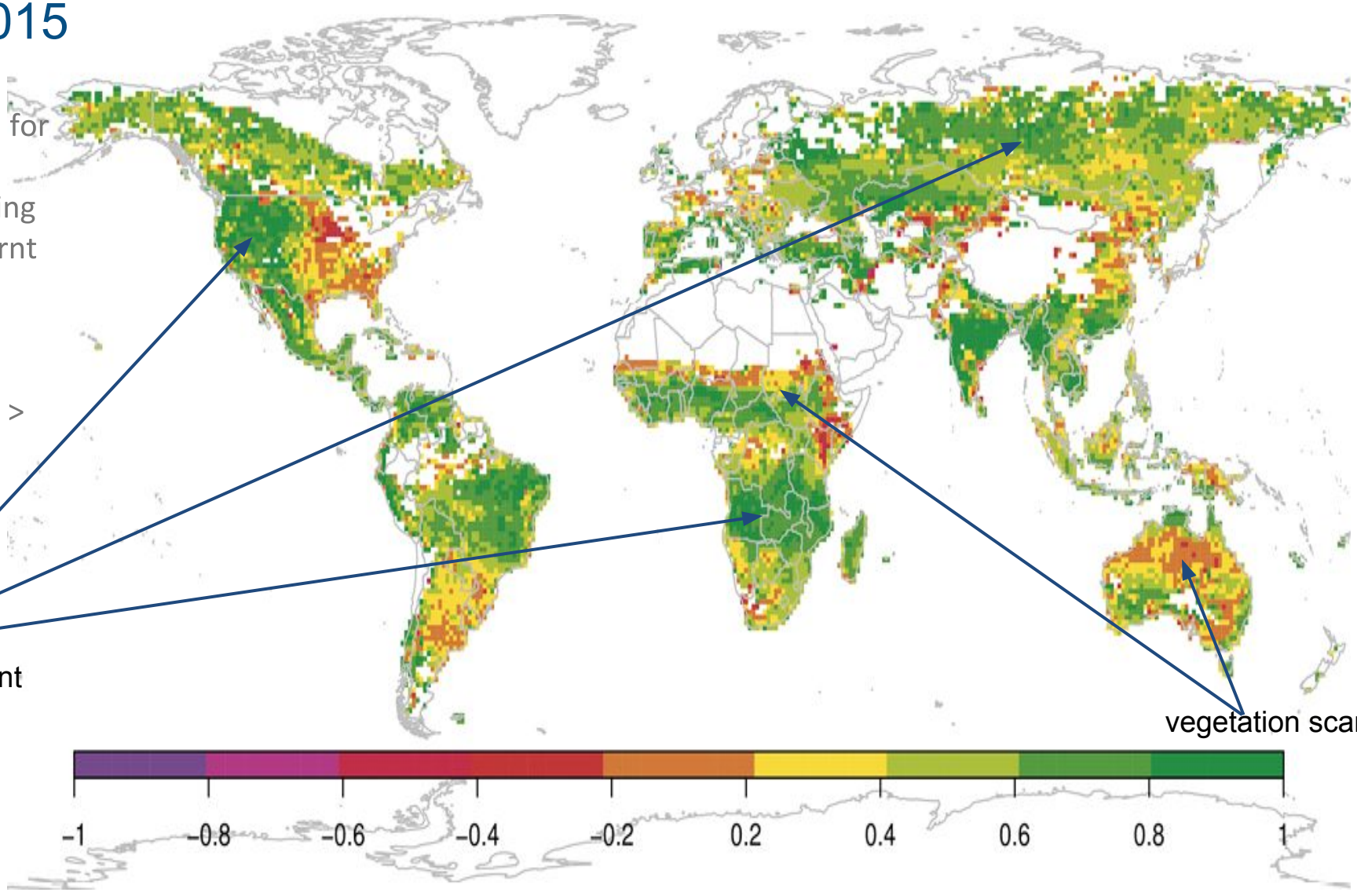
Quintilio, D.; Fahnestock, G.R.; Dubé, D.E. 1977. Fire behavior in upland jack pine: the Darwin Lake Project. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Information Report NOR-X-174.

Where FWI approach is likely to be more accurate to detect fire danger: reanalysis 2000-2015

Extremal Dependence Index (EDI) for the Fire Weather Index (FWI).
The EDI skill score is calculated using the fire mask derived from the burnt areas of the GFED4 dataset.

A fire is considered to have been forecasted when the FWI is above > 75% of its distribution.

EDI =1 perfect forecasts
EDI =0 random forecasts.



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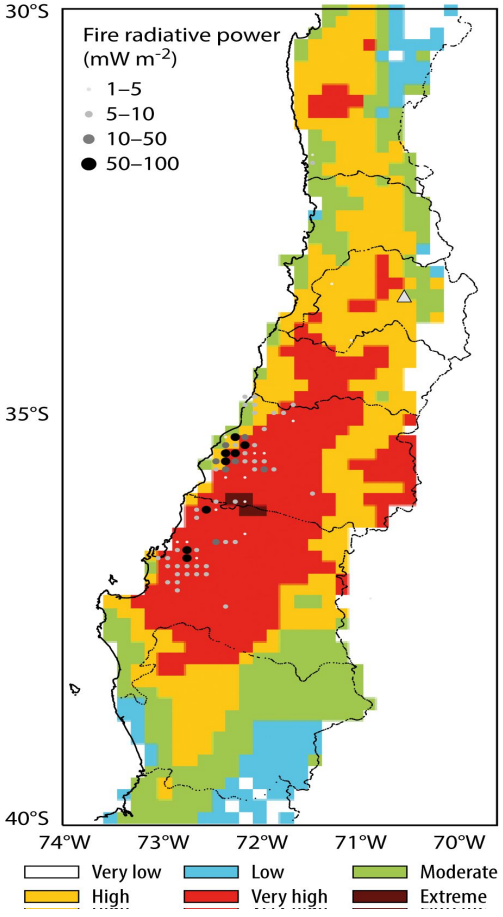
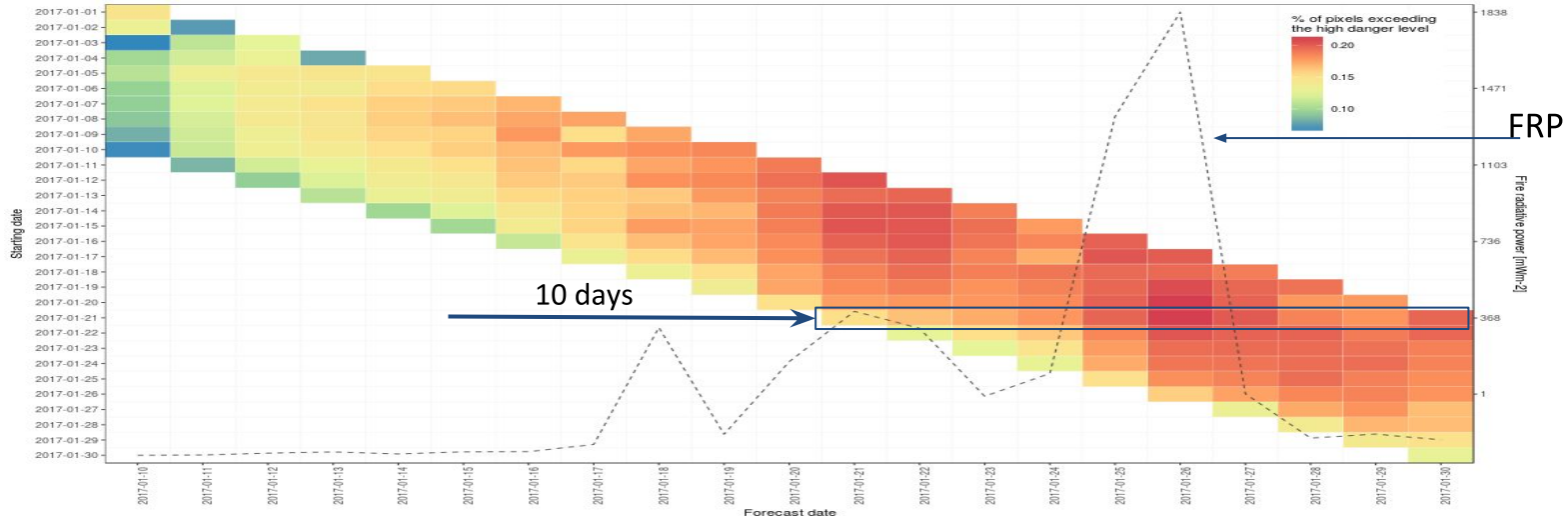
Di Giuseppe, F et al. "The potential predictability of fire danger provided by numerical weather prediction." Journal of Applied Meteorology and Climatology 55.11 (2016): 2469-2491.

How in advance can we forecast fire danger ?

Medium range (10 days ahead)



Fire danger classes. 5-day forecast of fire danger classes (shading) for Chile initialised on 26 January 2017 for the period 26–30 January, with GFAS fire locations and intensities (fire radiative power) for the same period.



January 2017

Strong winds, high temperatures and long-term drought conditions led to some of the worst wildfires in Chile's history during the last two weeks of January 2017. Fires in the central regions of O'Higgins, Maule and Bío Bío south of Santiago were widely reported by the global media.

The Emergency Response Coordination Centre of the European Commission (ERCC) reported that between 1 July 2016 and 2 February 2017 approximately 3,000 fires had affected more than 575,000 hectares and 6,000 people.

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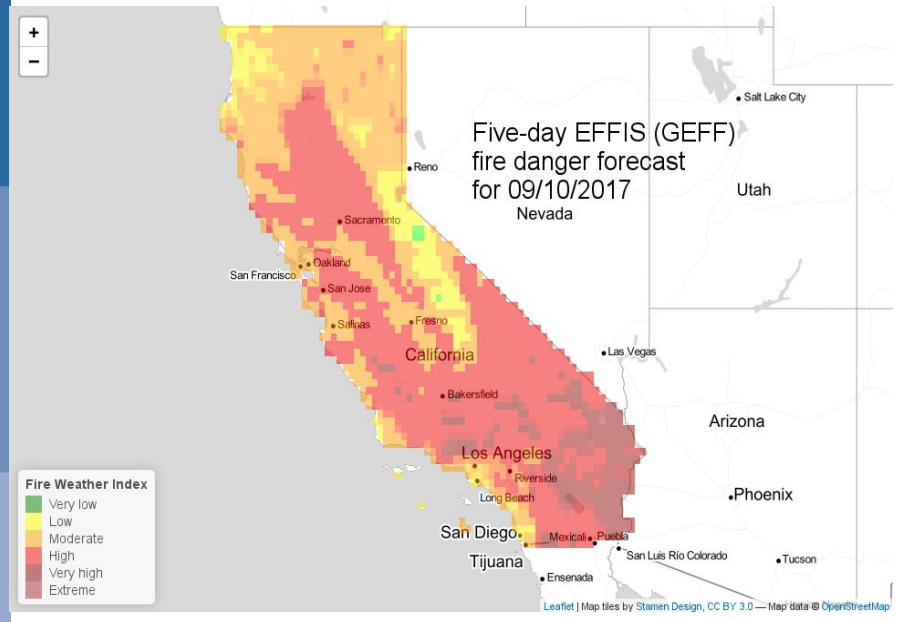
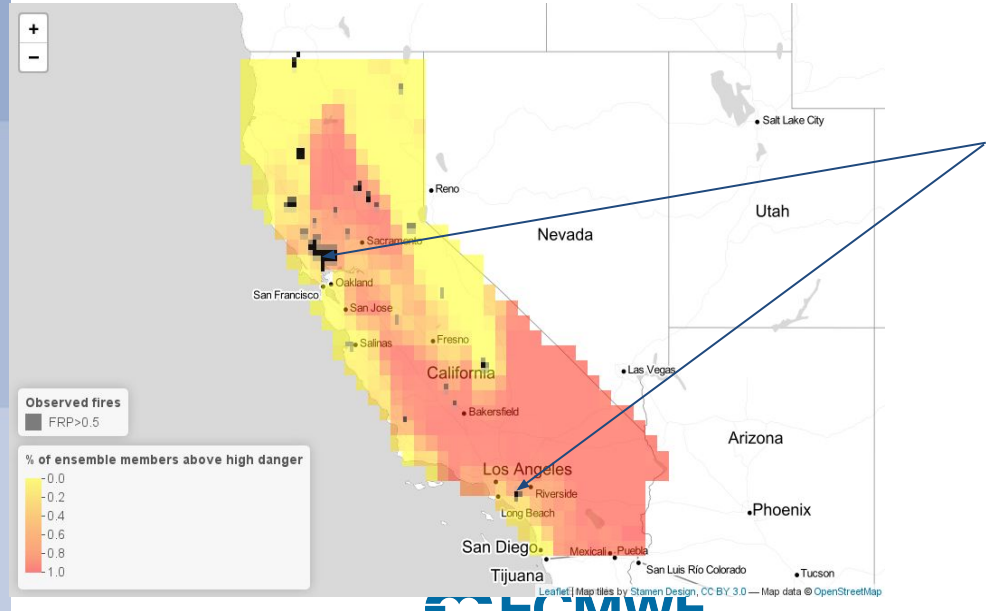
Another example: the California fire





California fire (8-11 October 2017)

The **2017 California wildfire season** was the most destructive wildfire season on record,which saw multiple wildfires burning across California. A total of 9,133 fires burned 1,381,405 acres (5,590.35 km^2), according to the California Department of Forestry and Fire Protection, including five of the 20 most destructive wildland-urban interface fires in the state's history.

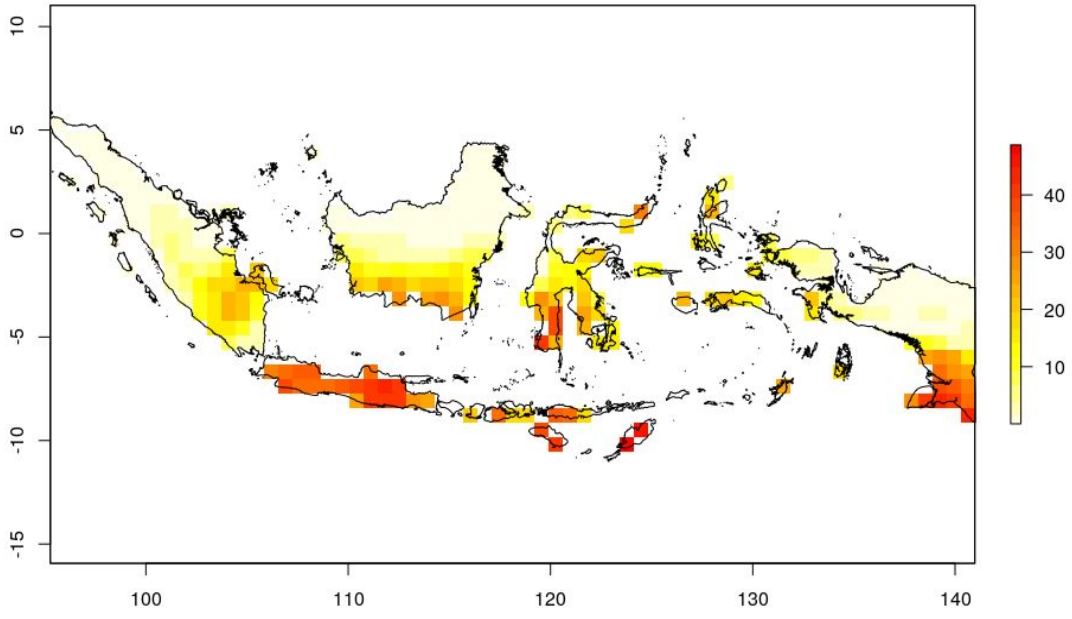
State data showed that the large wildfires killed 43 people – 41 civilians and 2 firefighters - higher than the previous 10 years combined

Observed fires

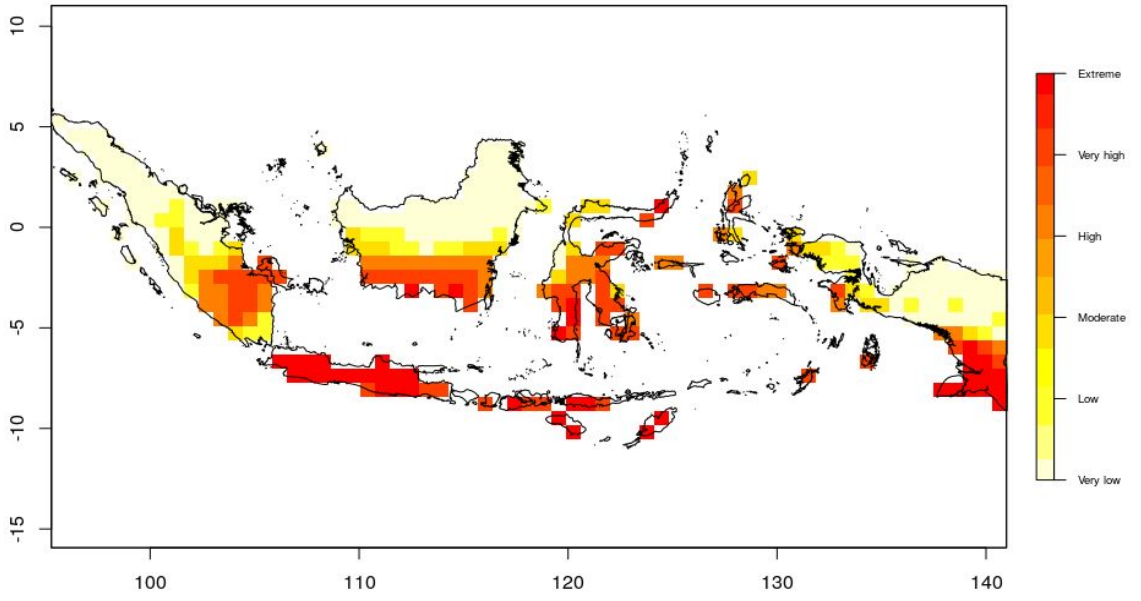
Probabilistic information provided by the fire forecast Ensemble prediction system

Long range forecast (46 days)- fire prediction

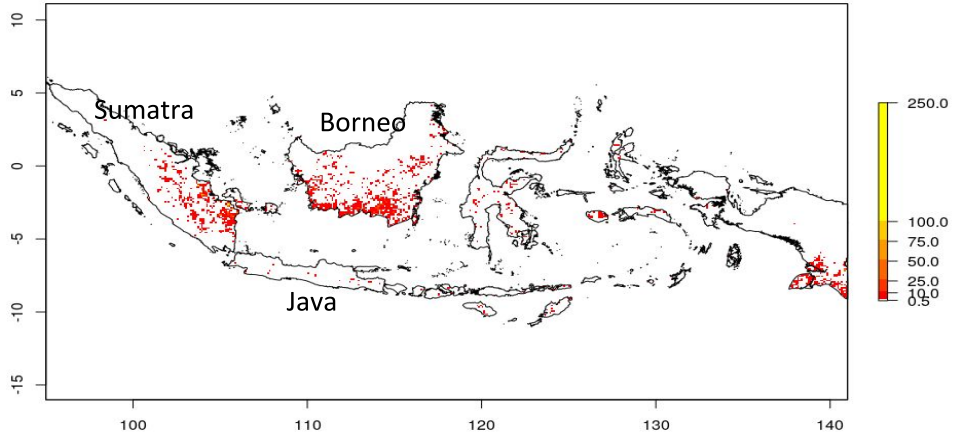
Uncalibrated mean September 2015 FWI



Calibrated mean September 2015 FWI



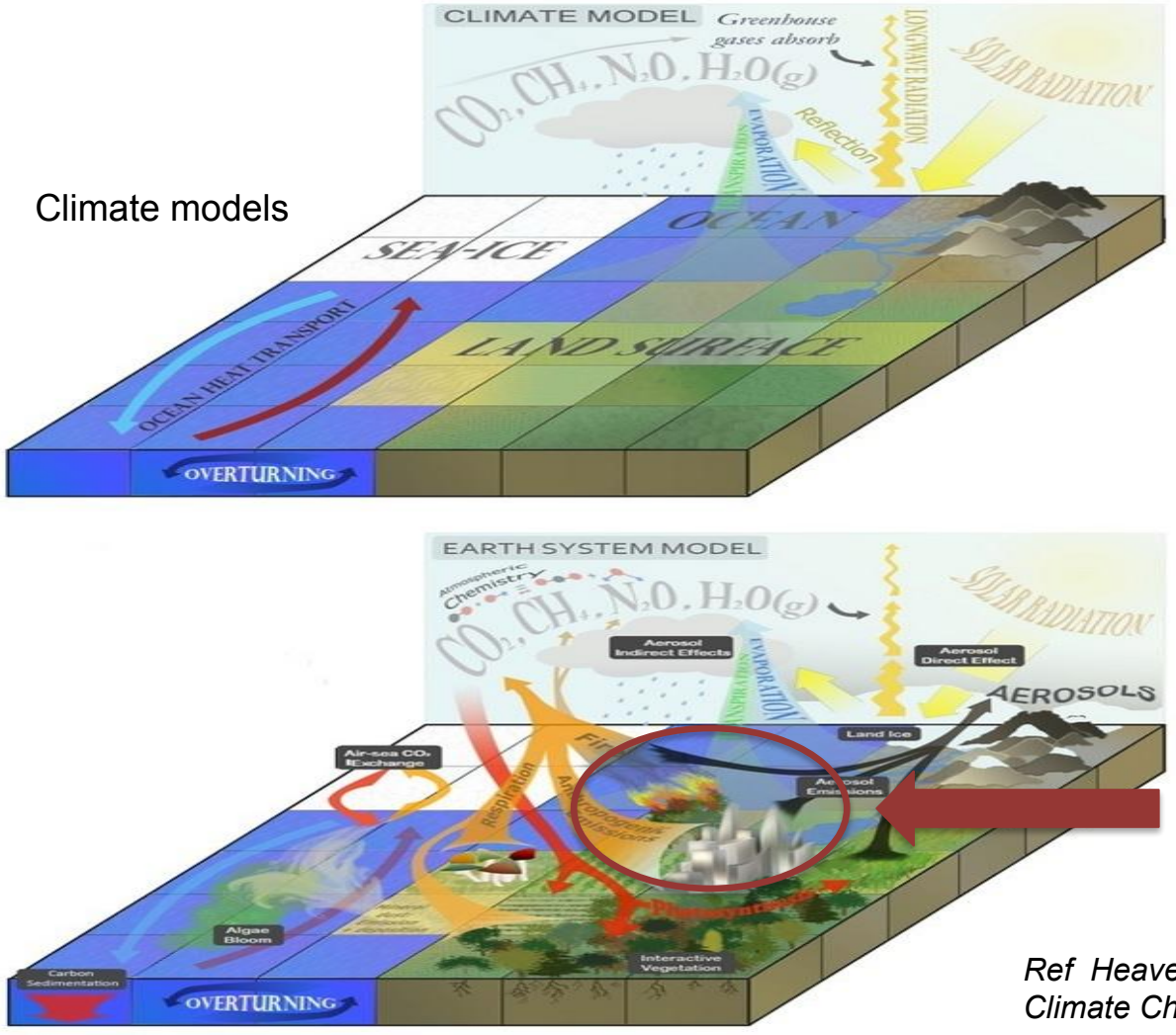
Danger Level	FWI value
Very low	0-2
Low	3-4
Moderate	5-9
High	10-16
Very High	17-28
Extreme	>28



in Indonesia human caused fires on peat soil rage out of control during extensive droughts which are mostly exacerbated during El nino conditions.

Increasing predictability: going toward earth system modelling

Climate models



Earth system models gain complexity by considering the biological and chemical processes that feed back into the physics of climate.

Note the prominent place of aerosols (eg. from fires) that are suspended in the atmosphere.

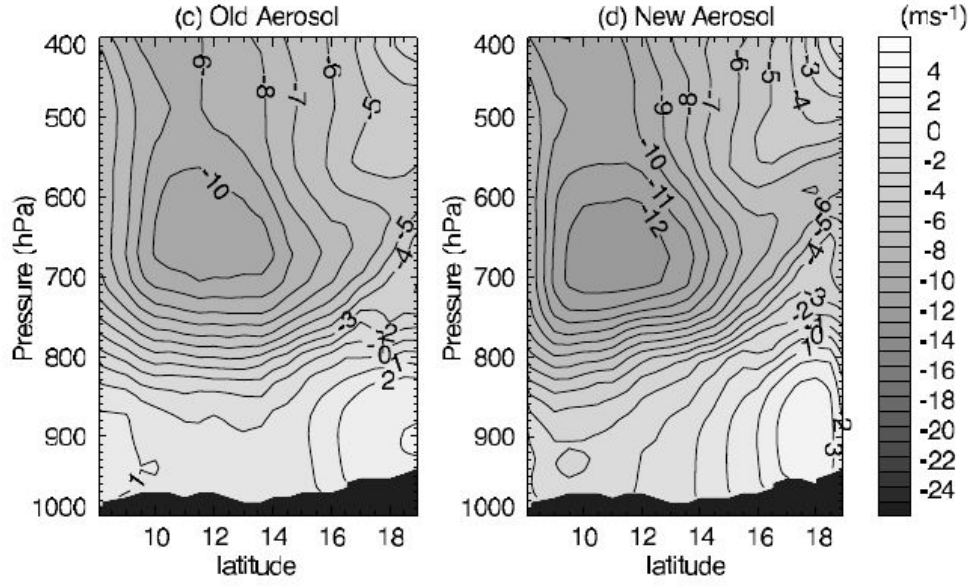
Aerosols can absorb and scatter visible and infrared radiation as well as serve as a medium for transporting nutrients over long distances.

Ref Heavens, N. G., Ward, D. S. & Natalie, M. M. (2013) Studying and Projecting Climate Change with Earth System Models. Nature Education Knowledge 4(5):4

Expected effect of aerosol on weather

Aerosols have a direct impact on radiative transfer - which can in turn impact dynamics

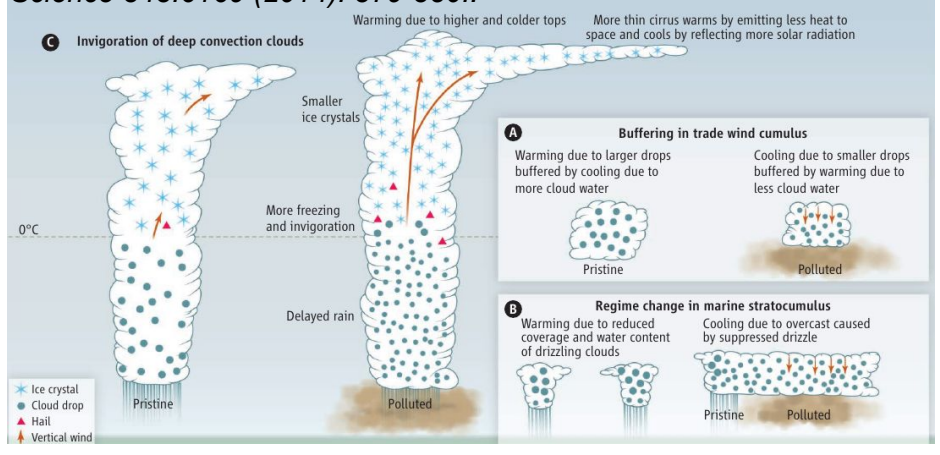
CHANGE OF AEROSOL CLIMATOLOGY INCREASES AEJ STRENGTH BY 20% AVERAGED OVER MANY ECMWF 5 DAY FORECASTS - Tompkins et al. 2005. Influence of aerosol climatology on forecasts of the African easterly jet. Geophys. Res. Lett., 32:L10801, doi:10.1029/2004GL022189.



Some biomass burning aerosols can act as cloud condensation or ice nuclei -

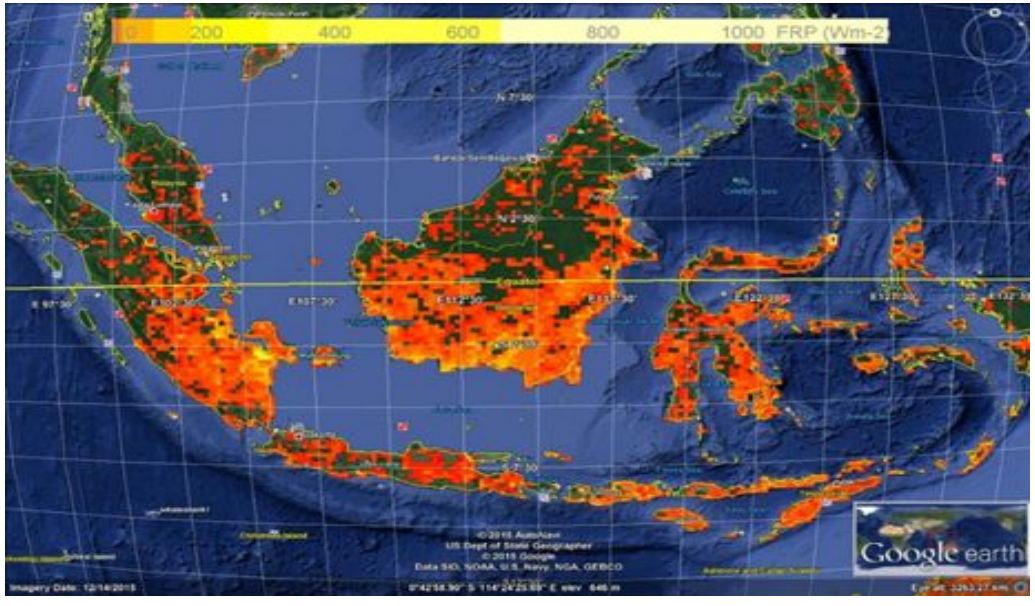
- For warm rain processes reasonably well understood, not so for ice processes.
- Interaction with cloud scale (unresolved!) dynamics complicates matters (see right)

Rosenfeld, Daniel, et al. Climate effects of aerosol-cloud interactions." Science 343.6169 (2014): 379-380..

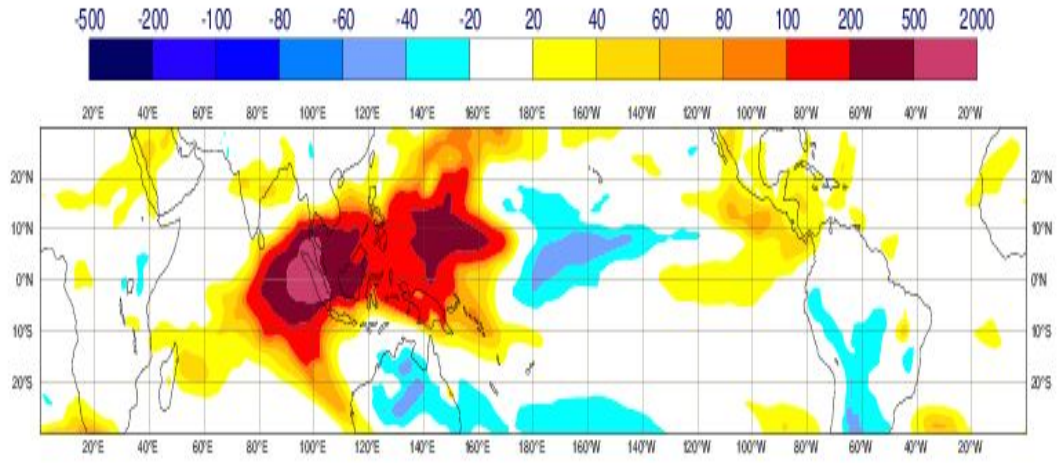


Local weather effect: Indonesian fires (Aug-Oct 2015)

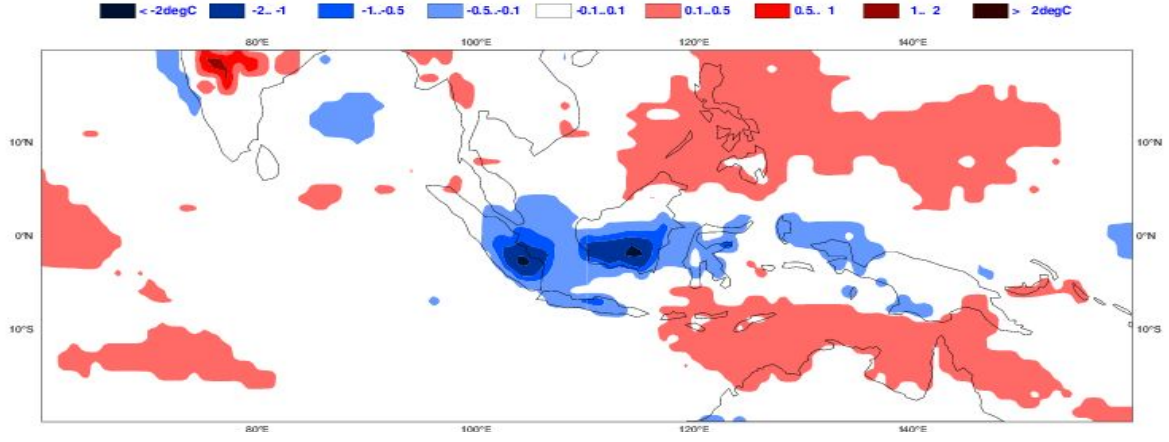
Fire radiative power Aug-Oct 2015



Biomass burning AOD anomaly: up to 2000%



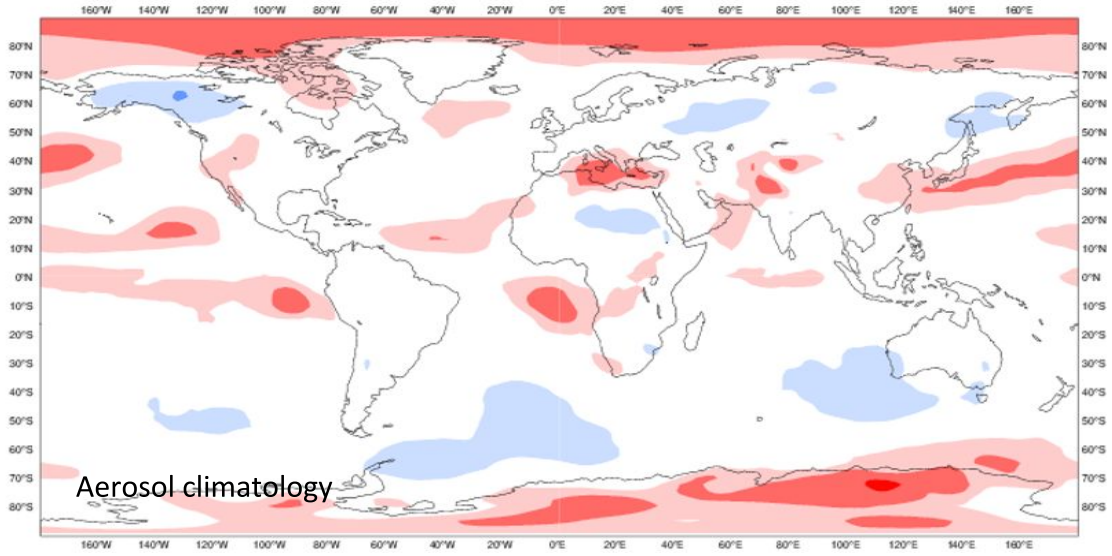
2m-tm anomaly Oct 2015 - Forecast starting 1st May

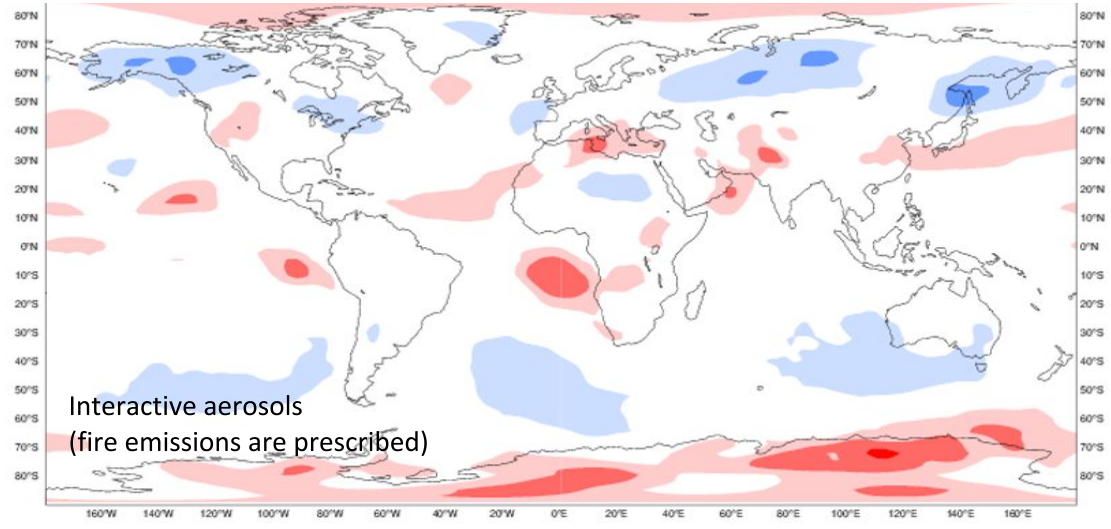


Benedetti A, Di Giuseppe F et al , State of Climate 2016, BAMS.

Benedetti A and Vitard F (2017) Can aerosols be a source of predictability at the sub-seasonal scale? Conditionally Accepted in MWR

Inclusion of aerosol in weather simulation: global effect 2





Reduction of Temperature bias at week 4

forecast started on 1 May for years 2003-2015

Verified against ERA-Interim

Benedetti A and Vitard F (2017) Can aerosols be a source of predictability at the sub-seasonal scale? Conditionally Accepted in MWR

Conclusions

Fire danger prediction to really be helpful should be accurate at least 3 days ahead (says to us the "Portugues met-service").

With today weather forecast accuracy this might be in reach, especially if information is complemented with "confidence" levels.

Fire danger prediction at the longer lead times (subseasonal to seasonal time scales) can help planning preventive measures.

We have seen that an extended predictability can be achieved under large scale conditions and if calculating fire danger anomalies (i.e warning levels definition, "calibration procedure")

Finally

The inclusion of evolving fires in weather forecast can enhance predictability especially at the longer lead times